PHOTO-MICROGRAPHY WITH OPAQUE OBJECTS.

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It is a matter of no little regret to the lover of the microscope and its wondrous revelations in the realms of Nature invisible to the unaided sight, that the wide class of subjects which may be embraced in the comprehensive title or term of Opaque Objects is so greatly neglected of late years. This is alike true of both modern instruments and observers. The microscopes of twenty years ago were abundantly supplied with objectives of moderate and low powers suited to their examination, and with accessory apparatus for their illumination under the most diverse conditions, whilst much space in the text books was devoted to the same subject. But with the general introduction of the instrument into schools of all grades and its practical employment in a multitude of arts and sciences, most of these accessories have been eliminated from its outfits, until a microscope as now generally furnished comprises merely a simple form of stand with a couple of objectives of moderate and fairly high powers and a double nose piece. "Only these and nothing more". Vast fields of investigation are undoubtedly within the scope of its capacities, but the wonderful beauties of form and outward structure in the untold myriads of Nature's lavish handiwork, remain but as a sealed book to the great majority of observers. With the aid of the most advanced modern methods in staining and cutting sections, the minutest structure of a tissue is revealed to the practised eye, which may be almost or entirely ignorant of that of its envelope. How many of the students of the present day know anything of a mucous surface for instance, injected with opaque pigments and viewed under a proper illumination? Yet nothing can be more beautiful or instructive. So too with

innumerable other subjects. The seeds of plants with their infinite forms and markings: pollens, spores, scales and hairs of leaves and stems, endless in variety and beauty. In the insect world we have the compound eyes of many a fly glowing with gorgeous beauty, the scales upon the elytra and bodies of many beetles, and the wings of butterflies and moths, the fairy-like eggs, among the loveliest productions of Nature. In the mineral kingdom may be found minute crystals of every form and hue. But it is useless to extend the list, it is inexhaustible in subjects that will repay the most careful examination for purposes of either study or recreation.

The reproduction of opaque objects as seen under the microscope, for purposes of illustration and record, is no less important than that of transparencies. As a matter of course—in the author's opinion—photography offers the most satisfactory method of so doing. With suitable lenses and careful illumination it is but little if any more difficult than the photographing of transparent substances, yet no one seems to have done anything heretofore in this direction, with the single exception of photographing metallic surfaces under high powers; a most important subject which has received considerable attention and added greatly to the world's knowledge of these structures, within the last three or four years. Excepting these, however, I have never seen a photo-micrograph of an opaque object, nor a single line from any pen bearing upon the subject. If such exist they have not come under my observation.

It is hoped that these few preliminary remarks may not prove useless or uninteresting as an introduction to the equally brief notes or hints as to the making of this class of photo-micrographs, the following of which has led to fairly good results in the author's hands.

Any microscope, with or without inclination to body, may be used. The results are better with, than without an ocular, and the latter should be, if possible, especially constructed for the purpose—as Zeiss' projection eyepiece for example. It should be capable of carrying and focusing a three-inch objective, which power is useful for many comparatively large or

coarse objects. The outfit of lenses should include a two-inch objective but need not go above ⅛, the most useful work being done with 1½-in. to ½-in. A plano-convex or bull's eye condensing lens on stand is indispensable. If possible, a Lieberkühn for each objective and a parabolic silvered reflector should be included in the outfit, though the latter pieces of apparatus are rarely found in these days with any microscope, especially of American manufacture.

Artificial illumination *may* be used; even the somewhat dim coal oil lamp, which, however, requires inordinately long exposures. The acetylene gas light is altogether the best from an artificial source I have ever employed, and is quite satisfactory in time and quality. But altogether the best light for the purpose is dffused daylight from a window with northern exposure, than which nothing can possibly be better. If the camera is constructed so as to permit the use of the microscope in a vertical position, so much the better, as proper lighting of the object is more readily secured than when the instrument is inclined horizontally, an even illumination, avoiding deep shadows, giving the best results in most cases, and this is the more readily obtained when the object lies in a horizontal plane. Some objects are better shown under a diffused light, such as may be obtained near a window without the interposition of a condenser. If its color be dark or reflect but little light, the bull's eye should be used focused upon the specimen, care being taken to avoid glare or excess of illumination which will result in a confused image in the negative. With some subjects the Lieberkühn may be used advantageously, with others the parabolic reflector, but the majority yield better results under the most simple forms of illumination. A very little practice will enable the operator to determine this for himself, in widely differing cases.

The character of plates to be used for the negatives is probably of more importance than those for transparent objects. They should be of a good degree of sensitiveness but not too rapid, must be capable of giving great density if desired and should develop equally well with all mediums, so that the

worker may employ that with which he is most familiar. The best and most satisfactory paper I have ever used is the "Velox", a modified bromide, capable of being handled by daylight but sensitive enough to be printed by lamp or gas-light, and giving black and white prints of the most exquisite and permanent qualities. The illustrations accompanying this paper are printed on "Glossy Velox" which I have found to yield results superior to those obtainable on the matt surface. Some specimens are better delineated by allowing the light from the sky to fall as nearly perpendicular as possible upon them. Others again show better by throwing the light obliquely across their surfaces by means of the bull's eye condenser or parabolic reflector. They should always be carefully studied under various methods of illumination before making any attempt to photograph them, in order to determine upon the best resolution and definition of their several features. No. 2 of the illustrations was made with the light reflected from a white cloud and falling directly upon the object without the intervention of a condenser. The others were lighted from the same source, but with a condenser so arranged as to throw the light across their surfaces, causing slight shadows. The result is strikingly shown in No. 3 from a slide of Cuxhaven diatoms, mostly discoid forms. As seen with the page in proper position, many of them present the appearance of shallow dishes or saucers, containing others of smaller dimensions; reverse the page and print and this appearance is entirely lost. With these three photographs the illumination was from the front of the microscope.

The possibilities of this class of photo-micrography for real work or recreation only, are very great; the field boundless. I trust that others may feel inclined to enter upon it and that we may hear from them in the future.

The explanation of Plate XXVII may be found in the text.